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A FRESHWATER ANAËROBIC CILIATE.

CHANCEY JUDAY.

Investigations on a considerable number of Wisconsin lakes have shown that, in many of them, more or less of the lower stratum, or hypolimnion, and the muddy ooze at the bottom possess no free oxygen for a certain time during the summer stagnation period (Birge and Juday, '11). This time varies from three or four weeks in some lakes to as many months in others. The dissolved oxygen disappears gradually from this stratum as the season advances and when it reaches a minimal amount the various organisms occupying this region respond to the change either by migrating or by adapting themselves to the new conditions.

When the minimum is reached for plankton crustacea they rise to a higher level where oxygen is more abundant and when this gas becomes too scarce for some of the bottom dwelling insect larvæ they migrate to the shallower water. The majority of the forms, however, are able to remain here even in the absence of free oxygen. To this latter group belong representatives of at least seventeen genera of protozoa, including rhizopods, flagellates and ciliates, but chiefly ciliates, and a number of higher forms, such as insect larvæ, an ostracod, worms, and a bivalve mollusk. These forms appear to thrive as well in water which contains no free oxygen as in water which is well aërated, thus being facultative anaërobes (Juday, '08).

While making a study of the centrifuge plankton of Lake Mendota a ciliate was found in the lower stratum of water which appears to have gone beyond the facultative stage so that it has become substantially a true anaërobe. This ciliate agrees very closely in shape and structure with Fig. 126, Plate X., of Conn's "Protozoa of the Fresh Waters of Connecticut," which this author "with hesitation" places provisionally in the genus *Enchelys*. It has uniform ciliation, a rather pointed, obliquely truncate anterior end, and a rounded posterior extremity. Frequently

the anterior third of the organism appears to be filled with minute granules which give this portion a somewhat darker color. The maximum length ranges from $35\ \mu$ to $40\ \mu$ and the greatest width from $15\ \mu$ to $17\ \mu$.

This ciliate was found each season from 1914 to 1917 inclusive, but it was most abundant in the former year and scarcest in the latter. The accompanying table shows its vertical distribution in four sets of observations which are typical of the entire series. This table also shows the relation of the organism to temperature, dissolved oxygen, and free carbon dioxide. The observations were made at a regular station where the lake has a depth of 23.5 meters.

TABLE I.

THIS TABLE SHOWS THE VERTICAL DISTRIBUTION OF THE CILIATE AND ITS RELATION TO TEMPERATURE, DISSOLVED OXYGEN AND FREE CARBON DIOXIDE.

Date.	Depth in Meters.	Number of Organisms per Liter.	Temperature, Degrees C.	Oxygen, c.c. per Liter.	Carbon Dioxide, c.c. per Liter.
October 10, 1914.....	14	0	17.4	1.67	2.50
	15	90,700	17.0	0.14	2.83
	16	58,900	16.3	0.00	3.92
	17	27,200	14.5	0.00	4.58
	18	0	13.8	0.00	5.14
October 21, 1914.....	17	0	15.2	0.60	3.53
	18	68,000	15.1	0.00	5.50
	19	68,000	14.6	0.00	7.92
	20	22,700	14.2	0.00	9.00
	21	9,100	13.3	0.00	9.24
September 22, 1915.....	22.5	9,100	12.6	0.00	11.00
	15	0	16.9	0.40	2.40
	16	27,200	15.9	0.00	5.67
	17	27,200	15.4	0.00	
	18	6,800	15.2	0.00	7.14
September 20, 1916.....	20	0		0.00	
	15	0	17.0	3.08	3.54
	16	13,600	14.8	0.00	7.33
	17	6,800	14.4	0.00	8.08
	18	6,800	14.0	0.00	8.84
	20	0	13.8	0.00	9.45

In 1914 regular observations were not begun until the first of September and this ciliate was first noted on September 16. The number rose to a maximum of 95,200 individuals per liter of water at a depth of 16 meters on September 29. From the latter date until October 21 the organism was abundant, but by October 23 the number had decreased 70 per cent., and by October

27 it had entirely disappeared. The autumnal overturn took place between the last two dates, with the consequent aëration of the water at all depths, and this event was followed by the prompt disappearance of the ciliate.

In 1915 this organism was found in small numbers in four sets of observations between July 12 and July 22. The stratum of water which it occupied at this time contained from 0.10 c.c. to 0.40 c.c. of dissolved oxygen per liter. Following the latter date it was not found again until August 19 and August 23 when a small number was noted in a stratum of water which contained no dissolved oxygen. It appeared regularly in catches made during September, the largest number being found during the latter part of this month. It disappeared between September 29 and October 6, the autumnal overturn and aëration of the lower water having taken place in the meantime.

In 1916 this ciliate was noted twice in July, but it did not appear again until September 18, when it was obtained during the following ten days. In 1917 it was found only in September and then only in small numbers.

This protozoan showed a downward movement each autumn which was correlated with the descent of the thermocline or mesolimnion, the organism keeping just below the stratum of aërated water. Thus in the table above it will be noted that the stratum occupied on October 21, 1914, was three meters deeper than that of October 10. This descent continued until the bottom was reached and then the ciliate disappeared promptly, usually within two days, after the bottom water became aërated. In the laboratory it lived in water that had been partially aërated only for a period of about twenty-four hours.

As indicated in the table there did not seem to be any correlation between the vertical distribution of this ciliate and the temperature of the water or the amount of free carbon dioxide, but there was a definite correlation with the lack of dissolved oxygen, the stratum occupied having at the most only a minimal amount of this gas and most frequently none at all. This fact and the further fact that it disappeared so promptly when the water became well aërated seem to warrant the conclusion that it is substantially an anaërobic ciliate.

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